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(54) **Improvements relating to the manufacture of containers**

(57) Drawn and ironed container bodies based e.g. on steel or aluminium are made from metal sheet blanks having on at least one of their surfaces permanently-affixed plastics film/adhesive laminate. The plastics film may be p.v.c., polypropylene etc. and the adhesive for example a maleic anhydride modified polypropylene. One surface of the blank, if only one is laminate-clad, can be coated with an abrasion and breakdown resistant organic resin composition, e.g. epoxy phenolic resin.

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SPECIFICATION

Improvements relating to the manufacture of containers

The present invention relates to improvements in the manufacture of containers, e.g. beverage or food cans.

Metal containers may be formed by various techniques including drawing and ironing, drawing and multiple draw techniques.

Drawn containers are manufactured by forcing a metal blank into a die while the blank is prevented from wrinkling by pressure exerted on a clamp plate. The clearance between the drawing punch and die assembly is such that the metal is not pinched or thinned, i.e. the drawing operation changes a flat blank, with little change in its thickness, into a hollow vessel in the form of a shell or cup. Drawn cups can be redrawn when taller cups are desired. A typical operation would involve the steps of blanking and drawing metal into a shallow cup and feeding the resulting cup through another die of smaller diameter, these steps being repeated as desired until a tall cup of the required shape and dimensions is obtained. Although the metal has changed shape several times and although a substantial reduction in the inside diameter occurs, the sidewalls and bottoms of the shells formed have the same thicknesses, equal to that of the original blank.

As used herein, and in the can-making industry, the term 'drawing' is defined as the forming of a recessed parts by forming metals in dies and refers to the operations wherein a peripheral margin of flat stock is turned inwardly and simultaneously smoothed by means of a punch and drawing die to form a cup having a wrinkle-free sidewall the thickness of which is neither substantially less than nor substantially greater than the thickness of the original blank.

In contrast to the manufacture of drawn cups by deep drawing or multiple drawing procedures, the manufacture of containers by a drawing and ironing procedure involves forming a cup from a relatively thick sheet of metal, e.g. by drawing, and then reducing the thickness of the sidewall of the cup by pushing it on a cylindrical punch or mandrel through a series of ring-like ironing dies. Each of these ironing dies has a slightly smaller inside diameter than the preceding one in the series. The metal is squeezed or ironed between the punch and the ironing rings and is forced up the punch to form a tall cylindrical sheet with walls thinned or reduced substantially from the original thickness of the metal stock.

As used herein, 'ironing' means the forming of a thin wall d, wrinkle-free cylindrical cup from a blank with sidewalls thinned from the riginal thickness f the blank, substantially no reducti n of the inside diameter of the cup occurring during th process.

Such drawing and ironing procedures, hereafter referred t as D&I, are acc mpanied by several problems f manufacture usually associated with the high radial surface pressure exerted n the dies. Becaus of this pressure, it is n cessary to use materials f v ry high strength and having a high modulus of elasticity for th producti n of the dies and tooling. Th presence of high radial surfac pressur can ngender a consid rable frictional force between the body of the container and the ironing dies, necessitating that provision be made for a lowered coefficient of friction. This has generally been accomplished by providing a polished die surface in combination with intensive lubrication using oily, greasy lubricants and intensive cooling of the dies and/or punch. Chemical and/or mechanical roughening have also been proposed to encourage retention of lubricant on workpiece surface in order to aid lubrication.

The workpiece itself may be e.g. steel, aluminium or tinplate, and the manufacturing process may involve either blank-fed or cup-fed ironing depending on the metal. With tinplate, for example, it is possible to form a D&I container shell directly from a flat blank of metal from a single stroke of a punch. In this procedure, circular blanks are cut from lubricated coil or sheet and fed directly into an ironing press. The first die in the press forms a cup around the punch and irons the cup wall slightly. The punch then continues moving through a series of dies which thin the sidewall to its final thickness. Such a procedure is possible with tinplate because of the great strength and drawability of steel. However, because of the high tensile and yield strength, variations in sheet thickness and low ductility of steel, many problems are associated with the extreme mechanical deformation encountered during D&I procedures involving this metal. Amongst the problems in particular are extensive galling and die wear due to metal-to-metal contact, unless tin is present on the surface.

It is possible also to employ a cup-fed procedure which involves a separate cupping press for forming a cup. The cup-fed ironer has a die stack similar to that employed for the blank-fed process except that it is preferably turned 90 degrees so that the punch moves in a horizontal plane. Gravity is often used to assist cup-feeding into the ironer. Cups generally need relubricating after forming and before ironing.

It has been proposed that certain organic resins, when applied to metal stock and partially cured under specific conditions to create appropriate viscoelastic properties, are capable of withstanding deformation during drawing and ironing without exfoliation or substantial fracture. See for example our British Patent Specification No. 1,517,732, the disclosure of which represents a significant advance over earlier D&I procedures. The earlier D&I procedures utilizing precoated stock had not been successful principally because of the extreme stresses imposed on the coating during the ironing operation, the buildup of heat in the apparatus, which often leads to the thermal breakdown of the coating, and frictional f rces xerted with tended to exf liate the coating.

It has n w been discovered that drawn and iron d containers may be pr duced fr m metal stock .g. aluminium, steel, having plastic film laminated to at least one surface f the stock, th resulting containers carryiny on their surfaces a film characterised by a degr e of toughness and abrasion-resistance that

is greater than that btained with solution or dispersion coatings.

Further details f the inv ntion will now be given by way of example only in the following description which discloses a preferred embodiment of the invention.

The method of forming D&I containers according to the invention broadly comprises the steps of:

a) providing a film laminate comprising a plastic film layer and adhesive resin film layer on one or both surfaces of flat metal sheet;

b) forming a workpiece from the film laminate-carrying metal sheet;

c) forcing the workpiece through a series of drawing and ironing dies on a punch to form an elongated cylindrical article, the sidewalls of which are substantially reduced in thickness relative to the thickness of the workpiece before passage through the dies, and

d) removing the article from the punch; the film laminate being capable of withstanding the drawing and ironing steps without exfoliation or decomposition of the film.

As will be disclosed hereinafter, the metal sheet can have the film laminate on one surface and a coating of an organic resin composition on its opposite surface.

Film laminae may be formed on metal sheet, e.g. strip or foil which may be 'as rolled' aluminium or steel as well as treated versions having electro-coated or other chemical conversion coatings such as Alodine treated aluminium, chromate-phosphate coated steel including blackplate, tinplate or other chemically treated steel. The laminae will comprise at least one layer of a polymeric plastics material and at least one adhesive resin layer, the compositions of which are broadly immaterial so long as the layers have adequate adhesion to the metal and are capable of withstanding the severe stresses encountered in drawing and ironing without exfoliation. Particularly preferred polymeric film materials are polyvinyl chloride and polyolefin materials such as polypropylene including propylene- ethylene copolymers. Suitable adhesive resin layers are maleic anhydride modified polypropylene; dispersions of maleic anhydride modified -polypropylene in epoxy-phenolic coatings such as B–6135 and B–6138 available commercially from M&T Chemicals; vinyl phenolics, for example L6X345, MM89 and MM99 available commercially from Midland Industrial Finishes; vinyl chloride-vinyl acetate copolymers, for example such copolymers containing at least about 50% vinyl chloride, for example such resins available commercially as VYHH, VMCH, VAGH and VMCC from Union Carbide Corp; and polyester based adhesive resins such as MAC–600 available commercially from E. I. DuPont.

The maleic anhydride modified-polypropylene resins, well known in the art and available commercially under the tradename HERCOPRIME from Hercules, Inc rporated are especially suitabl for bonding polypropylene. Such adhesives in general may be prepared by blending a pr pylene polymer with about 0.05 t 25% by weight based on the propyl ne polymer f a maleic anhydride-modified propylene polymer containing about 0.05 to 10% by w ight f ch mically combined maleic anhydride as described and claimed in U.S. Pat nt 3,483,276.

It will be understood that the particular adhesive will be selected according to the particular film employed and must be one capable of bonding to the metal as well as to the particular film. Thickness of the adhesive may range from about 0.05 to 0.30 mils (0.0013 to 0.0076 mm), preferably 0.1 to 0.2 mils, (0.0025 to 0.0051 mm). Thus for polypropylene and ethylene-propylene copolymers, the most effective adhesives will be selected from the maleic anhydride modified- polypropylene or dispersions of such modified polypropylene in epoxy-phenolic resins while for polyvinyl chloride the most effective adhesives will be the vinyl phenolic or vinyl chloride-vinyl acetate copolymers.

The laminae may be formed on the metal surfaces by any of several methods. For example, the adhesive may be applied to the metal by roller coating, spraying, dipping etc. after which preformed plastics film is adhered thereto, with or without heating to activate the adhesive, if necessary. Alternatively, the adhesive may be applied to the metal and plastics film extruded directly thereon or the plastics and adhesive may be coextruded and laminated to the metal plate. A polymer/adhesive film may be coextruded onto the bare metal or metal which has been given a receptor coating of adhesive. In a preferred embodiment herein, coextruded polypropylene/adhesive is produced employing the polypropylene homopolymer in one extruder and a blend of HERCOPRIME (maleic anhydride modified polypropylene) in a second extruder, the coextrusion resulting in a 1 mil laminate (0.025 mm) comprising 0.85 mil (0.022 mm) polypropylene and 0.15 mil (0.0038 mm) adhesive layer.

Desirably, the preferred polypropylene films are electrostatically treated prior to laminating to improve board strength and adhesion.

More specifically, a film laminate is formed on metal sheet, which may be aluminium or steel including blackplate, tinplate or other chemically treated steel and the laminate-clad metal is formed into a drawn and ironed container.

The plastic film chosen is one already exhibiting viscoelastic properties, so that a specific curing step is not necessary. Because of its viscoelastic properties, the resin prevents metal-to-metal contact at surface asperities while the workpiece is forced through a series of drawing and ironing dies.

Preferably, the film laminate is capable of exhibiting the following characteristics during the drawing and ironing steps:

1) it will require exertion of an ironing force of less than about 10,000 pounds (4545 kg) and a stripping force of less than about 1200 pounds (545 kg) as determined by a scr ening techniqu set f rth later hereinbelow;

2) it will exhibit good elongation, compressi n and plastic fl w under loading at temperatures up to about 500°F (260°C);

3) it exhibits malleability with good adhesion to metal stock without adhesion to tooling;

4) it will be abrasion resistant;

5) it will be capable of reflow at temperatures up to from ab ut 400°F to ab ut 450°F (circa 204 to 232°C) depending upon the particular resin and consistent with its degradation properties;

6) it will be capable of maintaining adhesion to the substrates as it is drawn and ironed without severe exfoliation;

7) it will be capable of being cleaned, topcoated and rebaked if required without decomposition or loss of adhesion;

8) it will prevent rust or corrosion of formed containers during storage prior to subsequent operations such as decoration or topcoat spraying;

9) it will not impart off-flavour or odor to products packed in the container and will act as a barrier to metal ion dissolution of the container metal into the product; and

10) it will be capable of withstanding subsequent metal forming operations such as bottom doming and top necking-in and flanging.

The stripping and ironing forces recited above are those obtained on a cup-fed bodymaker, Model No. HX50–20, Serial No. 561190–2, (Stolle Corp., Sidney, Ohio) for a 211 diameter can with a five die stack. Strain gauge on the ironing ram were employed to determine peak ironing force by measuring the compressive loading of the ram during ironing and the negative compressive forces, i.e. elongation, as the ram withdraws and the formed shell is stripped therefrom. While the forces recited have been found to be reasonably consistent when employing various types of bodymakers, to the extent that it is possible that these values may vary utilizing different apparatus, tooling, etc., they are viewed as a screening technique for evaluating the ability of specific film laminates to function in the D&I process and are given for purposes of illustration only.

While the exact physical and/or chemical phenomena that are responsible for the results obtained are not known, one very important function of the laminate is believed to be in its behaviour as a film lubricant, i.e. as a 'plastic solid' material interposed between the workpiece metal and the tooling which serves to lower the coefficient of friction permitting a lower punch force and lower stress levels in the container wall. However, many failures in the drawing and ironing process are triggered by 'stress risers', i.e. highly localized points of weakness caused by metal flaws or metal-to-metal contact between the workpiece and tooling which are not necessarily eliminated by placement of a film lubricant to lower the coefficient of friction between the workpiece and tooling. For example, the metal exhibits plastic flow in the dies at a stress level beyond the yield point defining the onset of plastic flow in the metal. At that str ss level, a localized breakdown f th film r films separating surface asperities n the w rkpiece and tooling could lead to a stress riser f r any of the f ll wing reasons: metal-to-metal contact causing a 'stick-slip' disruption of plastic fl w; metal-to-metal contact causing spalling f surface asperities generating particulate abrasive material to damage films, w rkpiece walls and tooling; welding of for ign particles to previously sm oth tooling surfaces; and/or localized heat generation sufficient t change the properties of the films or m tals involved.

It is believ d that th film laminae of this inv ntion, in addition to lowering the coefficient of friction, also tend to distribute high stresses due to surface irregularities over a wider area through the plastic flow of the film which is controlled by the stress state present as the container passes through the different operations of the D&I process. In contrast to Newtonian fluids such as water, oils, etc., which show a direct proportionality between stress and shearing velocity whereby internal slippage will occur in the film at any stress level, the plastic films of the invention appear to resist flow until a certain yield shearing stress is imposed. This yield stress is construed as the stress that must be exceeded before the cured, bonded film begins to flow. The distinction is believed to be a significant one, since the film laminate at a high stress level will be capable of functioning as a high viscosity 'filler' thereby minimizing the effect of surface irregularities and resisting breakdown, yet below that stress level, resists flow and serves as a film lubricant, characteristics that Newtonian fluids can not exhibit. Moreover, since in the D&I process, radial compressive stresses imposed by the tooling are transmitted to the metal through whatever resin or lubricant films are present, it is essential, if the effect of the film is to be maintained throughout the process, that the plastic flow characteristics of the resins comprising the laminae be compatible with the flow characteristics of the metal and that the film permit the development of higher stress levels without film failure. The D&I process involves at least four distinctly different operations, namely: blanking or cupping, redrawing, ironing and stripping; the film requirements being different for each operation because of variations in stresses inherent to each. The process increases the surface area of the metal so that elongation characteristics of the film are important if a major portion is to remain bonded to the metal surface. Additionally, localized compression of the film, which may affect film adhesion even more than elongation, is necessarily present in the cupping and redraw operations with the effect being most pronounced at the open end of the shell where the metal has moved through the greatest radial displacement from the flat blank cutedge. It has been found that the shearing stress history of the film varies with location depending upon which of the four operations and which portion of the container wall is under consideration. The requirements therefore for a film laminated to flat metql which will be functional in all the operations are much more stringent than those for any one of the operations alone.

The film laminae of the present invention are believed to satisfactorily combine th necessary viscoelastic pr perties including suitable contraction, el ngation; the ability to effect a l wer d c efficient of friction as well as the ability to r sist plastic fl w until a yield stress is imposed after which the resin flows distributing and minimizing the stresses during the process.

Measurement f th punch force required t m ve the w rkpiece through the diestack is used t sh w

appar nt changes in th coeffici nt f friction due to the pres nc of the film laminate on the metal surfaces by the screening technique discussed hereinabove and provides significant information from a few samples for evaluating film laminae.

Thickness of the laminae may vary as desired. In general, film thicknesses of 0.35 to 3.0 mils (0.009 to 0.076 mm) and preferably 1.0 to 2.0 mils (0.025 to 0.051 mm) have been found to be satisfactory.

The laminae may be formed on one or both sides of metal sheet. Where applied to only one side, e.g. the side destined to be the exterior of the container, the other side may be coated with an organic resin capable of withstanding the D&I process without exfoliation as described and claimed in our British Patent Specification No. 1,517,732 mentioned above. As disclosed therein, the metal sheet is coated with an organic resin, the sheet is subjected to an elevated temperature for a period of time sufficient to effect adhesion to the metal and a partial curing of the resin, and a workpiece is formed and drawn and ironed therefrom, the coating resin being cured to the extent that it is non-tacky, capable of effecting a lowered coefficient of friction, exhibits plastic flow, and resists breakdown at points of high stress during the D&I forming steps. Preferably, the resin is also cured to the extent that it does not generate ironing forces substantially in excess of 10,000 pounds nor stripping forces substantially greater than 1200 pounds when employing the screening technique disclosed hereinabove. Wall ironers will full stroke internal stripping as disclosed in U.S. Patent 3,967,482 when employed, will ease the stripping force requirements of the screening technique.

Optimum and preferred conditions for the coating resins have been found to be a cure of about 270°–380°F (circa 132 to 193°C) for about 6 to 8 minutes at a weight of about 5 to 30 milligrams.

The coating resin should be partially cured to the extent that it has adequate adhesion to the metal, is non-tacky and capable of withstanding the process without substantial exfoliation or fracture. When tacky, the resin film sticks to tooling and stripping forces are so high as to prevent successful practice of the process. For example, with an epoxy-phenolic resin applied as a coating and baked for six minutes at 240°F (115°C) the resin fails by sticking in the cupping press and requires a stripping force that is undesirable. Partial curing of the resin is indicated to be essential and such curing must be sufficient to prevent tack, to permit stripping and also to permit the resin to exhibit the viscoelastic properties and plastic flow necessary for its successful function during the forming steps.

Suitable coating resins have been found to be certain epoxy and vinyp resins, for example epoxy resins partially cr ss-linked with vinyl, amin or phenolic resins. Such resins include epoxy-phenolic resins, reaction pr ducts of the classic epoxy resin obtained by reaction of epichlorohydrin and bisphenol A, known in the art as diglycidyl ethers f bisphenol A, also referred to in the art as DGEBA resins, and other resins of this type derived from reaction of polyhydric phenols and epihalohydrins with phen l-f rmaldehyde type resins. Preferred DGEBA r actants are diglycidyl ethers of bisphenol A having averag molecular weights f from ab ut 900 to about 12,000, specially from 1,000 to 4,000 and epoxide equivalents of about 425 to about 6,000. In addition to the DGEBA resins, a variety of other epoxides may be employed including epoxidized novolacs. The phenolic component of the reaction product may be methylol phenyl ethers in which the H of the hydroxyl group attached to the phenyl group is substituted by an alkyl, alkenyl or cycloalkyl group, or by an aralkyl or aralkenyl group, as well as the halogenated derivatives thereof. These resins are A-stage methylol-phenol resins, i.e. soluble and fusible, and are disclosed and described in U.S. Patent 2,579,330. The preferred resin from this class is 1-allyloxy-2, 4-trimethylol- benzene. A preferred epoxy-phenolic resin, which also constitutes the preferred class of resin, preferably employed with suitable solvents, catalysts, etc. may be illustrated by a formulation comprising about 50 to 90%, preferably 70% Epon 1007, a DGEBA type epoxy resin having an epoxy equivalent weight of about 2000–2500, about 5–50%, preferably about 25% 1–allyloxy-2, 4, 6-trimethylolbenzene and about 1 to 8%, preferably 4%, polyvinyl butyral.

Epoxy urea formaldehydes are epoxy amino resins, derived by reaction of epoxy ethers such as DGEBA having an average molecular weight of about 900 to 4000, with the product of condensation of urea and formaldehyde in relative proportions varying from about 95 to 50 parts epoxide to about 5 to 50 parts urea-formaldehyde. Such resins likewise will have average molecular weights ranging from about 900 to 12,000 preferably 1000 to 4000 and epoxide equivalents of about 425 to about 6000. A preferred resin, preferably applied as a coating, may be illustrated by a mixture of DER667, a DGEBA epoxy resin having an expoxy equivalent weight of 1600–2000 and Plaskon 3300, a urea-formaldehyde resin. 'Plaskon' is a Registered Trade Mark'.

Vinyl organosols are well known compositions comprising polyvinyl chloride resins of relatively high molecular weight, usually at least about 15,000, which resins are relatively insoluble in the usual solvents and are designed to be dispersed in the liquid ingredients of the organosol. The high molecular weight resins are in a finely divided state, generally of a particle size of less than 5 microns. 'Vinyl organosol' as employed herein indicates dispersions of particles of vinyl chloride resins including not only the homopolymer but also copolymers of vinyl chloride with a vinyl carboxylate including vinyl acetate, vinyl butyrate, etc. usually containing at least 50% vinyl chloride in the vinyl copolymer structure. Dispersants include oxygen-containing polar solvents including ketones, e.g. diisobutyl ketone, isophorone; ether alcohols, e.g. 2-butoxy than l; other glycol ethers, e.g. diethylene glycol monobutyl ether; esters, .g. ethyl acetate as well as hydrocarbons, e.g. benzene, toluene and mixtures ther f. Also suitable as adhesion pr moting solution resins are other resins including poxy resins, melamines, acrylinc resins, phenol f rmaldehydes, etc. A preferred composition containing this resin type may b illustrated by a dispersion comprising about 80%

polyvinyl chloride with a 20% soluti n resin mixture comprising poxy, acrylic and urea-formaldehyde resins.

Solution vinyls are also a well known class of resin compositions and include vinyl chloride polymers, the homo-polymer as well as copolymers of vinyl chloride with vinyl acetate or other vinyl carboxylates, dissolved in suitable solvents including those mentioned above used as dispersants for the organosols and particularly ketones such as methyl ethyl ketone, hydrocarbons such as benzene, toluene, and mixtures such solvents. Additionally, the vinyl resins, which are of low molecular weight, usually below about 15,000, may be dissolved in or contain other resins in the solution including epoxides, melamine, phenol-formaldehydes, etc. A preferred composition containing this resin type may be illustrated by vinyl chloride-vinyl acetate copolymer containing about 1% maleic anhydride.

The coating resins identified above may be formulated in suitable solvents or dispersants with pigments and/or fillers and/or internal lubricants, as desired, by means well known in the art. The particular additives, whether solvents or dispersants etc. are not especially critical. It is necessary, however, that the solvents or dispersants be volatile at the baking temperatures indicated and that they be compatible with all ingredients of the composition in their useful concentration.

The film laminae are formed on one or both sides of the metal with or without heating to improve adhesion to the metal. In operation, it is preferred to first heat the adhesive layer to activate the same, apply the film layer and then post heat to improve the adhesion. Where the film is applied to one side and a coating resin is applied to the other side, these steps may be performed in either order, i.e. the film laminate may first be formed and then the organic coating resin applied and cured, or the steps may be reversed. It is essential however, where the coating resin is applied first, that the forming of the film laminate be done at a temperature that is insufficient to cure the resin to the extent that it will not be capable of withstanding the drawing and ironing step without decomposition as discussed hereinabove.

The following example will serve to further illustrate the invention.

EXAMPLE

Film laminates were prepared on panels of 103 lb TFS–CMQ steel as follows:

A. An adhesive comprising a maleic anhydride modified polypropylene dispersion in an epoxy-phenolic coating comprising about 70% epoxy DGEBA type resin, about 25% 1–allyloxy-2. 4. 6-trimethylol benzene and about 4% polyvinyl butyral was applied to both sides f the metal panels. The coat d metal was baked for 6 minutes at 380°F (193°C) to volatiliz solvents and cure the adhesive after which the adhesive bearing metal was cooled and preheated for 21 seconds in a 400°F (204°C) ven t activat the adhesive. Clear polyp- r pylene film was applied t b th sides f the metal panels carrying adhesive and subjected to a post-bake f 30 second in a 400°F ven to optimiz adhesion of the film t th substrate. There was thus produced a laminate comprising 1 mil (0.025 mm) polypropylene/0.1 mil (0.0025 mm) poxy-phenolic adhesive/TFS–CMQ ste l/0.1 mil poxy-phen lic adhesive/1 mil polypropylene.

B. The procedure of part A was repeated except that the adhesive was a vinyl phenolic, a preheat of 55 seconds was employed, the plastic was polyvinyl chloride film and the postbake was conducted for 45 seconds. There was thus produced a laminate comprising 1 mil polyvinyl chloride/0.1 mil vinyl phenolic resin/TFS–CMQ steel/0.1 mil vinyl phenolic resin/1 mil polyvinyl chloride film.

C. Film laminates of 1 mil polypropylene/0.1 mil epoxy phenolic and 1 mil polyvinyl chloride/0.1 mil vinyl phenolic were produced on one side of several panels of CMQ steel using the above procedure wherein the adhesive coated metal was preheated for 40 seconds at 400°F before lamination and post heated 30 seconds at 400°F and 20 seconds at 400°F for the polypropylene and polyvinyl chloride, respectively. The reverse sides of the laminated panels were coated with an epoxy phenolic resin composition at a coating weight of 10 mgs. and cured by baking in an oven at 300°F (149°C) for about 6 minutes.

2.610 in. diameter by 0.0113 inch thick × 2.250 in. in height (66.3 × 0.29 × 57.1 mm) cup as well as 5.694 in. diameter by 0.145 in. thick (144.6 × 3.68 mm) blanks were formed from the laminated metal prepared in parts A to C above. The cups and blanks were placed over drawing and ironing die assemblies – see for instance Figures 1 and 3 of our British Patent Specification 1,517,732 – in a can body-maker. In the cup-fed procedure, a punch forces the cup through the ironing dies, which progressively results in drawing the cup into a shallow seamless cup having a sidewall thickness of 0.0102 inch (0.26 mm) in the first die and 0.0062 inch (0.16 mm) in the second die. As the punch continues to force the metal workpiece through the die assembly, the shallow cup is elongated and the sidewalls are ironed through passage through the ironing dies to a final elongated thin-walled 5 inch (127 mm) container, having a sidewall thickness of about 0.0038 inch (0.10 mm) and a bottom wall thickness of 0.0113 inch which corresponds to the thickness of the original blank, that is subsequently removed from the ironing punch by a stripping operation. In the blank-fed procedure, the blank is forced through the drawing and ironing dies which results in a shallow seamless cup having a sidewall thickness of 0.0125 inch (0.32 mm) in the first die, 0.0108 inch (0.27 mm) in the second die, and 0.0055 inch (0.14 mm) in the third die, resulting in a final elongated, thin-walled 5 inch container having a sidewall thickness of 0.0055 inch and a bottom wall thickness of about 0.0145 inch (0.37 mm).

The containers, with b ttom profile imparted, ar n w r ady for subsequent treatment as desir d, including washing, decorating, coating, necking-in and flanging t produce a finished container. In the preferred embodiment, the desired bott m profile is formed by the ironing punch as abov describ d. It is to be understood, however, that while this exampl employs a three-die stack, the number f dies may be varied as desired to pr duc th container.

C mparable results may be obtained wh n th abov example is repeat d with ther film laminated metals such as tinplate and aluminium.

As will be apparent from the example, the film laminae may be applied to one or both sides of the metal sheet and may correspond to either the interior or exterior surface of the container. The drawing and ironing process herein described may be operated without actively applying heat between the various forming steps as illustrated in the above examples. It is conceivable, however, that there may be instances wherein it may be desirable to apply heat between the steps to relieve the stresses built into the resins during forming and, when desired, such stress relief may be achieved herein by heating to a temperature below the degradation temperature of the particular resin film employed for a period sufficient to relieve the stresses.

Various lubricants known in the art may be employed to aid in lowered the coefficient of friction between the workpiece and the apparatus, if desired. Auxiliary lubricants whether internal or external to the resin precoats suitable for use herein may include any conventional compounds, as long as such compound does not soften or tackify the resin film applied to the metal or otherwise adversely affect its properties during the process. Examples of suitable external lubricants include dioctyl sebacate, dibutyl debacate, mineral oil, acetylated tributyl citrate, deionized water, Prosol, etc. Dioctyl sebacate, acetylated tributyl citrate and/or water are especially preferred as the auxiliary external lubricant herein, since it has been found that use of such compounds is effective to eliminate or at least simplify subsequent washing steps. For example, the containers may be cleansed merely by baking in an oven at a temperature sufficient to remove the dioctyl sebacate, when dioctyl sebacate is the auxiliary lubricant, without the necessity for further washing. 'Prosol' is a Registered Trade Mark.

Examples of suitable internal lubricants include amide type waxes, e.g. ethylene bistearamide; alkyl aryl siloxanes; ester type lubricants e.g. dioctyl sebacate, acetylated tributyl citrate, tallow; glycol fatty acid esters; hydrocarbon type lubricants, e.g. mineral oil, higher molecular weight waxes; lanolin, spermaceti, polyolefin based lubricants, polytetrafluoroethylene lubricants etc.

When such auxiliary lubricants are employed, they may be used in proportions ranging from 1 to 15% by weight of the dry film.

The present invention provides a ready means for simplifying the conventional steps involved in manufacture of a D&I container. These steps, after forming, normally involve trimming, washing, decorating, interior coating, necking, flanging and palletizing.

Thr ugh ut the h retofor conventi nal m tal-forming and trimming operati ns, for example, the container shell is n rmally cover d by a film of oily lubricant which must be rem ved prior to decorating by cleaning, usually with heated aqueous det rgent sprays. In a typical washer, cans are conveyed through a series of cleaning and tr ating z nes. After cleaning, the surfaces of iron d metal, esp cially tinplat or blackplat , must be chemically passivated to prevent darkening during baking and to prev nt loss of enamel adhesi n. Th final step in a washer usually is a deionized water rinse to eliminate residues from the spray solutions. The ecological and economical importance of this invention becomes readily apparent when it is considered that the resins utilized and the film laminae may eliminate the coatings normally applied to containers after forming for decoration, as size coats for protection against corrosion, etc. With tinplate and blackplate particularly, conventionally the entire bottom end must be sprayed with organic coating or otherwise treated to prevent rusting. The container of this invention, as formed, already has present on its surfaces a protective and/or decoratable plastic film which protects against corrosion and makes it possible to eliminate the necessity to apply a size coating after forming. The container as formed provides a base for applying decorative top coats and the problem bottom end, which is particularly hard to protect by conventional means, is protected as formed. Moreover, oily lubricants are not necessary in forming and thus do not have to be removed, or if a lubricant is employed, it can be selected to be a volatile one, for example, the dioctyl sebacate above described, which can be baked off, virtually eliminating the need for multiple washing steps and washing equipment. Elimination of large numbers of heated aqueous spray applications would result in substantial energy savings, which is an increasingly significant feature and advantage.

Additionally, containers derived from stock carrying organic resins and film laminae appear to exhibit better adhesion to a wider variety of inks, and coatings and top-coats where utilized, may be applied at reduced weights. The adhesion to a variety of inks is particularly important, since currently only a few inks and varnishes are satisfactory for use with unsized tinplate because of poor adhesion. The present invention provides a greater variety in the selection of such inks. Another advantage is in the technique of film labelling wherein decorated labels of plastic film are adhered to the container surface. Adhesion of such labels to containers having organic resin film applied, as formed herein, has been found easier to obtain and greatly simplifies film labeling procedures.

Reflow of the film laminae and coatings which may occur during forming or subsequently during washing, decorating or interior coating, may effectively heal and eliminate metal exposure both on the interior surfaces, thereby preventing metal ion dissolution into products, and on the exterior surfaces, resulting in a container having a glossy surface finish. Such reflow further improves adhesion and serves to remove any flaws in the resin film that may result fr m the forming p ration. Where the container is intended f r use with mild, non-corrosiv products such as beer it is p ssible to eliminate the conv nti nal spray t pcoat completely, since a refl wed plastic film functions to prev nt metal dis-s lution into the product. Since galling is substantially eliminated, higher speeds are possible and di wear is minimized.

It is appar nt from the foregoing descripti n of th process that the rganic resin films n the interi r and exterior sidewall surfaces of the drawn and ironed container are subjected to extreme and varying mechanical actions. The internal sidewall surface is forced to undergo a 90° compressive bend around a punch and a tensional force during ironing, whereas the exterior sidewall surface undergoes the 90° tensional bend in the drawing and is then exposed to an extrusion or 'squeezing' action when passing through the forming dies. The bottom end of the container has not been essentially deformed. It is apparent that the exterior resin film on the container has undergone a deformation and change different from that of the interior resin film. With each ironing step, the interior resin film undergoes severe deformation as it is squeezed between the particular ironing face and the mandrel or punch. On the other hand, the organic resin film on the exterior surface of the container is thinned by each succeeding ironing die which reduces the thickness of the sidewall and increases its height, so that the resin film on the exterior sidewall of the container has been forced to undergo a 90° tensional bend in the drawing operation and then elongation or stretching during the ironing.

It should be noted that both the interior and exterior surfaces of the bottom end of the container retain the as-deposited organic resin films.

Containers made by the method disclosed hereinbefore can feature film laminates on both the interior and exterior surfaces of their bottom ends and sidewalls; the sidewall laminates but not the bottom end laminates, of course, have been subjected to the effects of drawing and ironing. If desired, the film laminates may be confined to, say, the interior end and sidewall surfaces of containers made as disclosed above. In some cases it may be desired to produce containers having the film laminates on either their interior or exterior surfaces. The laminate and coating are provided on the metal sheet from which the container is to be shaped before commencing the D&I procedure. Accordingly, the laminate and coating in the sidewalls of finished containers have both been subjected to the effects of the D&I procedure.

It is thought that the invention and many of its attendant advantages will be understood from the foregoing exemplary description and will be apparent that various changes will be made in the form, construction, and arrangement of the parts and in the steps of the method described and their order of accomplishment, without departing from the invention as claimed.

CLAIMS

1. A method of drawing and ironing thin-walled cylindrical articles fr m flat metal sheet comprising the steps of:

a) providing a film laminate comprising a plastics film layer and an adhesiv resin layer n at least one surface of the metal sheet;

b) f rming a workpiece from th film laminate-carrying sheet;

c) forcing the workpi c on a punch through a plurality f drawing and ironing dies to f rm an elongated cylindrical article, the sidewalls f which are substantially reduced in thickness relative to the thickness of the workpiece before passage through the dies; and

d) removing the article from the punch; the film laminate being capable of withstanding the drawing and ironing steps without exfoliation or decomposition of the film.

2. The method according to claim 1, wherein the metal employed is steel or aluminium.

3. The method according to claim 1 or claim 2, wherein the workpiece which is forced through a series of ironing dies in a seamless cup.

4. The method according to claim 1, wherein the film laminate includes a polypropylene or polyvinyl chloride plastics material as the film layer.

5. The method according to claim 4, wherein the film layer is a polypropylene plastics film, and the adhesive is a maleic anhydride modified polypropylene or a maleic anhydride modified-polypropylene dispersion in an epoxy-phenolic resin.

6. The method according to claim 4, wherein said film layer is a polyvinyl chloride plastic film and the adhesive comprises a vinyl chloride-vinyl acetate copolymer, vinyl phenolic or polyester adhesive resin.

7. The method according to any of claims 1 to 6, wherein the film laminate is formed on both sides of the metal sheet.

8. The method according to any of claims 1 to 6, wherein the film laminate is formed on one side of the metal sheet.

9. The method of claim 8, wherein the film laminate is formed on the surface of the metal sheet destined to become the interior surface of the cylindrical article.

10. The method according to claim 8 or claim 9, wherein prior to forming the workpiece, the method comprises the additional steps of applying an organic coating resin to the other surface of the sheet and subjecting the coated sheet to an elevated temperature for a period of time sufficient to effect adhesion to the metal and curing of the said resin to the extent that it is capable of withstanding the drawing and ironing steps without exfoliation or decomposition.

11. The method according to claim 10, wherein said coating resin is selected from epoxy-vinyl, epoxy-phenolic, epoxy-amino, vinyl organosol and solution vinyl resins.

12. A method of drawing and ironing thin-walled cylindrical articles from metal sheet comprising the steps of:

a) pr viding a film laminate comprising a plastic film lay r and an adhesive resin layer n one surfac f the steel sheet;

b) applying an organic resin composition t the opposite surface f the sheet;

c) subjecting th resin coated sheet to an elevated temperature for a peri d f time suffici nt to effect adhesion t the metal and a partial curing of the resin;

d) forming a workpiece fr m the laminated and resin-coat d sheet;

e) f rcing the workpiece on a punch through a plurality of drawing and ironing dies to from an elongated cylindrical article the sidewalls of which are substantially reduced in thickness relative to the thickness of the workpeice before passage through the dies: and

f) removing the article from the punch: the film laminate and organic resin being capable of withstanding the drawing and ironing steps without xfoliation or decomposition.

13. The method according to claim 12, wherein a lubricant is applied to the resin-coated sheet after step c).

14. The method according to claim 13, wherein the lubricant is selected from dioctyl sebacate, acetylated tributyl citrate, mineral oil and water, and mixtures thereof.

15. The method according to claim 12, 13 or 14, wherein the coating resin is selected from epoxy-phenolic, epoxy-vinyl, expoxy-amino, vinyl organosol and solution vinyl resins.

16. The method according to claim 12, 13 or 14, wherein a polypropylene film laminate is formed on one surface of the sheet and an epoxy-phenolic resin is applied to the other surface of said sheet, the first surface being destined to become the interior surface of the cylindrical article.

17. The method according to any of claims 12 to 16, wherein a seamless drawn cup is formed from the film laminate resin-carrying sheet, and the cup is placed over axially aligned drawing and ironing dies and forced through the dies with a reciprocal punch to form an elongated cylindrical article having a sidewall the thickness of which is substantially reduced from the sidewall thickness of said cup, said resin being cured in step c) to the extent that it is retained on the metal surface, exhibits plastic flow at high stress levels, and effects a lowered coefficient of friction during the drawing and ironing steps.

18. The method according to claim 17, wherein the metal employed is steel.

19. The method according to any of claims 12 to 18, wherein the coating resin is selected from epoxy-phenolic, epoxy-urea formaldehyde, vinyl organosol, and solution vinyl resins.

20. The method according to any of claims 12 to 19, wherein the laminate film comprises a polypropylene or polyvinyl chloride.

21. A method of drawing and ironing thin walled cylindrical articles substantially as herein described in detail.

22. A method of drawing and ironing thin walled cylindrical articles in accordance with Example 1.

23. A drawn and ironed container when made by the method claimed in any of claims 1 to 22.

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